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ABSTRACT

The primary focus of this paper is on examining the inter-relationship of those parameters which affect the costs associated with various forms of telecommunications services. The basic limitation in the scope of this paper is that cost will be examined primarily in a relative sense rather than on an absolute basis. We feel that a summarization of actual dollar costs for alternative forms of telecommunication services or a detailed explanation of existing common carrier rate structures would only serve to confuse the issue or result in an oversimplification of the cost problem. This paper then will only refer to specific costs for the purpose of illustrating specific points or general trends. (Other papers from this conference are available as LI 003360 - 003373 and LI 003375 through LI 003390) (Author)

Telecommunications Costs

by

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August, 1970

TELECOMMUNICATIONS COSTS

Introduction

This paper primarily focuses on examining the inter-relationship of those parameters which affect the costs associated with various forms of telecommunications services. The basic limitation in the scope of this paper is that costs will be examined primarily in a relative sense rather than on an absolute basis. We feel that a summarization of actual dollar costs for alternative forms of telecommunication services or a detailed explanation of existing common carrier rate structures would only serve to confuse the issue or result in an oversimplification of the cost problem. This paper then will only refer to specific costs for the purpose of illustrating specific points or general trends.

Telecommunications Parameters

Telecommunication costs are a function of distance, amount of usage, and channel capacity. In addition, the form of the transmitted information and the inherent characteristics of the transmission media affect telecommunication costs. For example, a page of information in the form of an analog video signal would represent approximately 630,000 bits of information when digitally encoded while the same amount of information could be represented by about 24,000 bits if encoded in a digital data form. Telecommunications costs will be highly dependent on the media chosen for storage of the media chosen for storage of the information prior to transmission.

Distance

Transmission distance is a fundamental parameter affecting telecommunication costs. Telecommunication rate structures are such that total cost increases with distance while cost per unit distance either decreases or remains constant with increasing distance.

Amount of Usage

Telecommunications usage has a direct effect on cost. Existing common carrier tariffs allow the user to select either full-period or shared telecommunications services. One example of a shared service is the DDD network. Charges for this service are directly related to the length of time the service is used. On the other hand full-period service charges are fixed since the user has the transmission facility dedicated to his sole use 100 percent of the time. If a user does not utilize the facility all of the time the cost per unit time utilized increases.

Channel Capacity

Channel capacity refers to the maximum limitations on information transfer imposed by the particular nature of the telecommunications facilities being utilized. Capacity is generally measured in terms of bandwidth (hertz or cycles/second) or data rate (bits/second). It should be noted that there is not necessarily a one-to-one correlation between the two measures for a particular communication facility.

The relationship between channel capacity and telecommunication costs is not easily definable. It is highly dependent upon the nature of the material being transmitted, the mode of transmission, and the types of avail-

able terminal equipment. Also there is a definite trade-off between channel capacity and utilization time. However, this is only true in those situations where real time communications is not a fixed requirement. Voice communication, Picturephone, and live television channel capacities are dictated by signal quality considerations.

Existing Telecommunication Services

Existing telecommunication services, as exemplified by the tariffed offerings of AT&T, encompass a broad range of channel capacities and pricing arrangements. The voice grade channel with a nominal bandwidth of 3 kilohertz is the basic building block of virtually all telecommunication service offerings. Table 1 lists the hierarchy of telecommunication channels. The groupings illustrated are not arbitrary but reflect the manner in which common carriers have historically combined channels in a physical sense.

In making some basic comparisons about the costs associated with existing telecommunications services one can divide these services into three catagories. Narrow band services include those services which are classically referred to as telegraph, utilize digital transmission rather than analog, and operate at speeds of 150 bits per second and below. Medium band services are those which are classically referred to as voice grade, utilize analog transmission rates up to 9600 bits per second. Wideband services are those which are classically called group and super-group band widths and are greater than voice grade. Wideband facilities will handle data rates in excess of 9600 bits per second, with maximum data rates determined by the specific type of facility being used.

TABLE 1

HIERARCHY OF TELECOMMUNICATION CHANNELS

Channel Designation	Nominal Band Width	Equivalent Voice Channels	Approximate Cost Ratio
Telegraph Channel	75 kHz	1/18	1/2
Voice Channel	3 kHz	1	1
Group	48 kHz	12	10
Super Group	240 kHz	60	30
Sub-Master Group No. 2	960 kHz	240	85
Sub-Master Group No. 1	1440 kHz	360	Not Tariffed
Master Group	2400 kHz	600	Not Tariffed

Costs of Existing Services

When one examines the cost structure associated with existing services several facts immediately become clear. Cost comparisons between narrow band and medium band services indicate that except in special situations where very low volumes of data transmission are involved that medium band or voice grade facilities are the more cost effective choice. For example, at a distance of 1000 miles, full period telegraph facilities, with a maximum speed of 150 bits per second, are available at approximately $800 per month while full period voice grade facilities which can handle much faster data rates are available for a basic price of $1100 per month. Again, at the same distance on a switched basis, narrow band TWX charges are $.50 per minute, while as direct dial voice grade charges are $1.15 for the initial three minute period. Even at the present time, there are serious questions with respect to the cost-effectiveness of narrow band telegraph type facilities and services.

With respect to trade-offs in the cost of both medium band and wide band services there is little that can be said that would be meaningful because the particular type of service which would represent an economic choice is highly dependent upon the actual or projected traffic characteristics of the system in question. The general relationship between cost of medium band and wide band services is that the basic wideband service (a group equivalent to 12 voice channels) is approximately 10 times more costly than a single medium band voice grade channel. This is true for both switched and full period private line services. The actual channel capacity available to users of medium band and wide band services

TABLE 2

TRANSMISSION COSTS
(1000 Mile Distance)

Facility	Bandwidth	Speed	$/megabit (approx.)
** Telpak C	240 kHz	250 kbps	$ .05
** Series 8000	48 kHz	50 kbps	$ .09
* Data Phone 50	48 kHz	50 kbps	$ 1.20
** Series 3000	3 kHz	9.6 kbps	$ .08
* DDD	3 kHz	2.4 kbps	$ 2.70

* Terminal Charges Not Included

** Assumes 24 Hours 7 Day/Week Utilization

is dependent upon the terminal equipment which is utilized. For example, on medium band services there are modems commercially available to handle transmission speeds from approximately 75 bits per second up to 9600 bits per second.

Table 2 illustrates the cost per megabit transmitted for some of the commonly available telecommunications services. The costs shown are minimum rather than average and are based on 100 percent operating efficiency. The basic conclusion to be drawn from the existing structure of telecommunication costs is that peak information volume is a highly critical factor affecting not only total telecommunications costs, but the per unit volume cost as well.

Trends Affecting Future Telecommunications

Certain trends now evident are expected to have a dramatic effect on telecommunications costs over the next two decades. This section identifies those trends and discusses the likely effect on telecommunication costs. Most cost reductions in the future will be the result of developments in two areas, technology and regulatory policy. The primary areas which we will examine are the following:

- Picturephone
- Digital Transmission Systems
- Data Compression Techniques
- Special Service Common Carriers
- Competitive Forces

Digital Transmission

The existing telecommunications network utilizes both analog and digital transmission systems. Analog systems are by far the most common at the present time, but digital carrier systems are being installed at a rapid rate. The primary difference between these systems is the manner in which information is represented. Digital systems transmit information as discrete signals while analog systems encode information into continuous signals.

On a cost basis digital transmission systems will be approximately equivalent to analog transmission systems of equal voice channel capacity. The primary advantage with digital transmission systems is their ability to inter-mix various type of signals and achieve more efficient transmission of signals other than voice.

An example of the efficiency of digital systems can be seen by comparing the equivalent bit rates on digital and analog voice grade channels. On analog systems 9600 bits per second appears to be the highest practicable bit rate that can be obtained now and, because of certain constraints in much of the telecommunications network, this is much more likely to be 4800 bits per second. On a digital transmission system one voice channel is equivalent to 56,000 bits per second.

Another example of the efficiency of digital transmission is Picturephone. Although the Picturephone set produces an analog signal it is possible to sample and encode the signal for digital transmission. Picturephone signals transmitted on an analog system displace either three or four hundred

voice channels (depending on whether the transmission media is microwave or coaxial cable radio relay). Picturephone signals transmitted on a digital system displace 96 voice channels. As a further example, one can obtain 250 kilibits per second transmission today on the equivalent of 60 voice channels on an analog super-group, whereas the Bell System T-2 carrier, which is scheduled to be installed initially this year, is a digital system that will provide 6.3 megabits per second on the equivalent of 96 voice channels.

There are other more advanced digital transmission systems under development which will have data transmission capabilities far in excess of the input/output data rates that present day computers can handle. For example, the T-5 carrier system, which is a high capacity long-haul carrier scheduled for initial installation around 1975, has a per channel data rate in excess of 5,000 megabits per second. Millimeter wave transmission systems utilizing wave guides and optical systems using lasers are expected to be placed into service in the late 1970's or early 1980's. These systems are expected to have data transmission capacities in the neighborhood of 25,000 megabits per second. We expect, because of these advances, that data transmission costs are likely to drop by a factor of two by 1974 and very likely by a factor of five by 1980.

Initially, digital transmission facilities will only be used for common carrier inter-office transmission. However, by the mid-70's digital transmission capability will be extended to user premises.

Data Compression

Advances in data compression techniques will effect the cost of trans-

mitting analog and digital signals. These techniques are expected to be particularly effective in reducing the cost of transmitting such analog information as facsimile or video. This will be done by digitally encoding the analog signal prior to transmission in such a manner so that a large percentage of the redundancy is eliminated. Bell Labs has indicated that they may be able to substantially reduce the equivalent voice channel transmission requirements for Picturephone using techniques of this type. Similar techniques can be easily applied to encoding the transmission of analog images stored on microfilm, video tape, or by facsimile.

Data compression encoding techniques are also applicable to digital data. One such technique in use at the present time eliminates excess transmission of repetitive blanks or zeros. There are also highly efficient variable length codes available for alphabetic information which take advantage of the frequency of occurance of the letters of the alphabet in the English language.

Special Service Common Carriers

With the MCI decision the Federal Communications Commission gave the go-ahead for the establishment of special service common carriers who will offer private line communication facilities for both analog and digital transmission in competition with the telephone carriers. These carriers are proposing price schedules which are substantially below those currently provided by the established common carriers. We expect that approval will eventually be granted for the establishment of these special service common carrier net-

works, although it will be approximately three to five years before these services will be universally available. Although these carriers are proposing to provide telecommunications services at costs substantially lower than the Bell System it remains to be seen whether or not these price schedules are realistic and whether or not the proposed rates are actually compensatory.

Competitive Forces

With the advent of the special service common carriers we are beginning to see the development of competitive forces within the telecommunication industry with respect to the offering of common carrier services. It is likely that the existance of the special service common carriers, or even the threat of their existance, will cause some radical departures from past practices on the part of the Bell System and other telephone companies in the manner which they determine their rates. The Bell System has stated that if the MCI type carriers are allowed to compete with them on their high usage routes that Bell will very likely will have to drop its previous policy of national averaging when establishing rates. The alternative approach which they will likely develop is to base rates between cities on the actual cost of the facilities installed. The experimental tariff for Series 11000 channels which is now in effect does in fact constitute a step in this direction. The overall effect of such a change in rate making philosophy will substantially decrease telecommunication costs for rural and less heavily populated areas in the country.

Conclusions

Telecommunications costs are highly dependent on the volume of information transfer, system response time requirements, and the form of information storage media utilized. Existing trends point toward technological developments which are expected to radically reduce the cost of transmitting digital data, however, no equivalent reduction in the cost of analog information transmission is expected.

Typical data communications costs on a per megabit basis have a variation of almost 2 orders of magnitude. Full time utilization is the key to achieving maximum economies in information transfer. Long-term telecommunications economies can only be achieved when the network design process allows for the technological advances which are likely to affect the telecommunications cost structure. Failure to anticipate these technological strides will result in networks which may be nowhere near optimum in even as short a period as five years. In addition, a lack of anticipation may result in the selection of information storage media which results in an extremely expensive conversion at some future date.